New Proton Conductive Composite Materials with Co-continuous Phases Using Functionalized and Crosslinkable TFE/VDF Fluoropolymers

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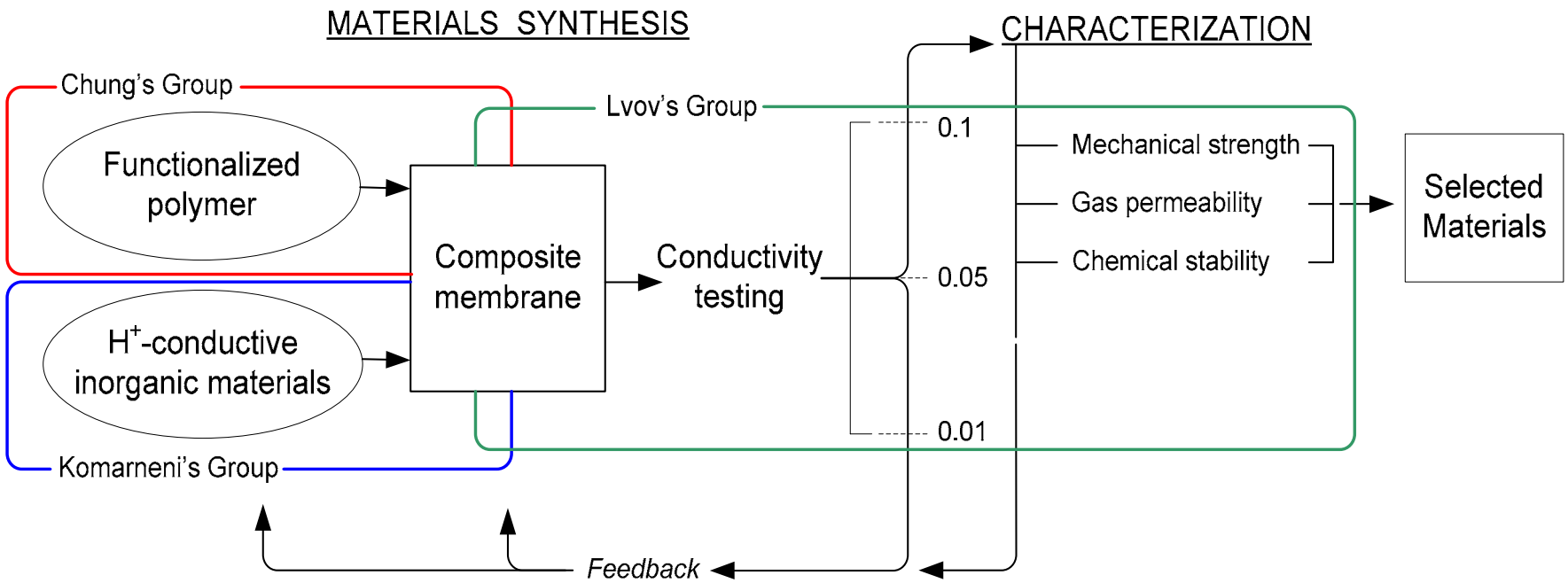
Project Objective

Develop a new composite membrane material with hydrophilic inorganic particles as a major component and TFE/VDF polymers as a matrix to be used in a PEMFC in temperature range of -20 to 120^{o}C and relative humidity range of 25-50%.

Project Organization

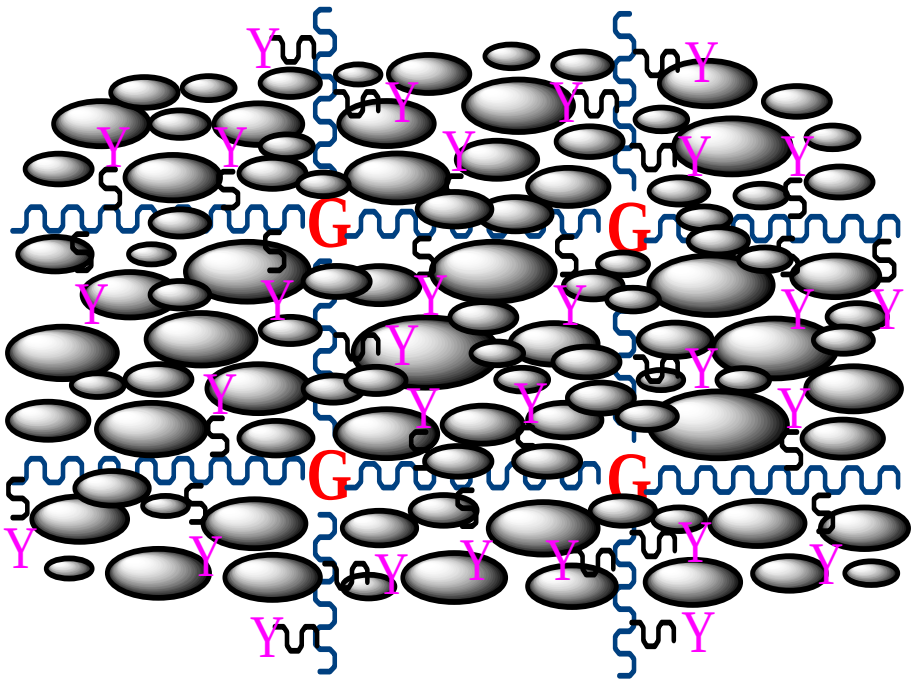


Three research groups will be involved in a loop of continuous synthesis and serial testing until the final product meets the target requirements.

Approach

- **We will synthesize a poly[vinylidene fluoride]-based polymer with chain–end functional groups which is highly compatible with the inorganic surfaces.**
- **We will synthesize a number of highly hydrophilic proton conductive inorganic materials such as structured metal phosphates, mesoporous oxides, etc.**
- **We will develop an approach to incorporate high loads of hydrophilic inorganic particles into the polymer.**

Anticipated Structure of Inorganic/Polymer Composite



: Teflon-segment

G : Crosslinker
(C-Si-C or C-Si-O-Si-C)

Y : Polar functional group

: Proton-conducting material

Preliminary Studies

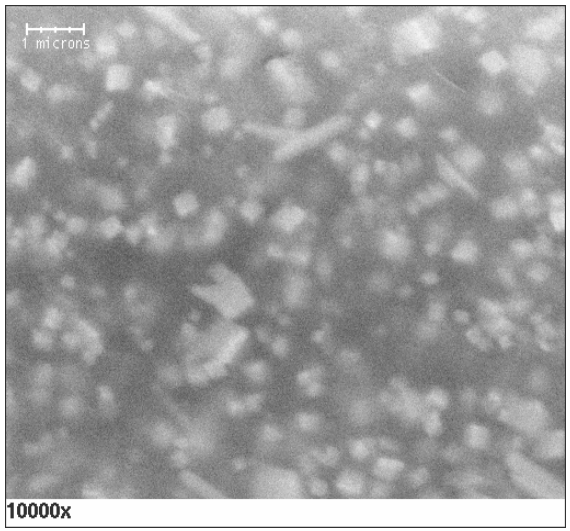
In our preliminary study, an inorganic/organic composite membrane containing 60% of 3-D structured $H_3OZr_2(PO4)_3$ and 40% of functionalized poly[vinylidene fluoride] with Si- terminal groups and Si-OH functional groups was fabricated.

T, °C	Water uptake, wt.%	
	New composite material	Nafion®
23	0.9	28
100	1.1	27

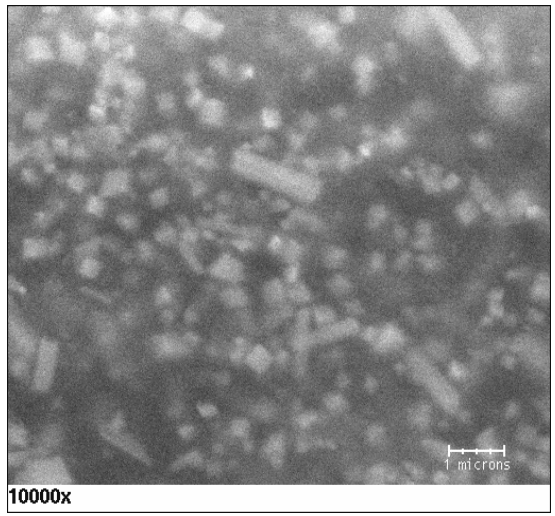
T, °C	Conductivity in Water, S/cm	
	New composite material	Nafion®
120	0.07	0.17
140	0.1	0.1

In contrast to Nafion, the composite membrane's conductivity continued to grow as temperature increased from 120 to 140°C. At 140°C, it reached the same value as conductivity of a Nafion membrane. The new membrane has a very low water uptake.

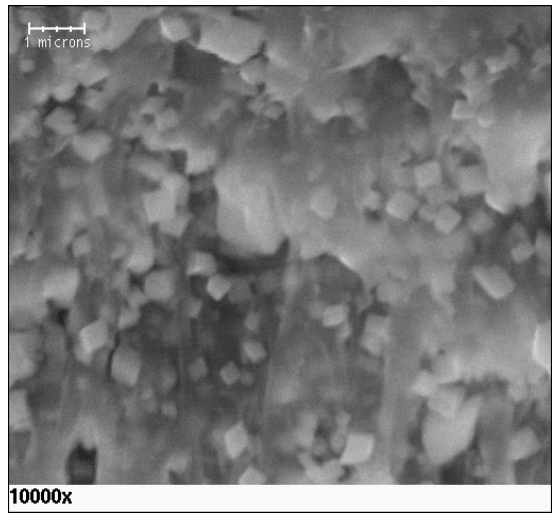
Preliminary Studies



a



b



c

SEM images of the new 60% $H_3OZr_2(PO_4)_3$ / 40% PVDF(Si) membrane: (a) and (b) show the surface on the opposite sides of the membrane and (c) is the cross-sectional image.

Based on the surface images the distribution of inorganic particles (300-500 nm in size) inside the membrane is uniform.